Evaluation of The Pack: Integrating a Computational Thinking Game in Middle School Classrooms

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Contents

Exhibits

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Executive Summary

With funding from the U.S. Department of Education, the New York Hall of Science (NYSCI), Participate, and the American Institutes for Research® (AIR®) partnered together to develop and study the Pack, a digital game and set of curricular and professional development resources that aim to support computational thinking teaching and learning in middle school science and computer science classrooms. “Computational thinking” refers to a problem-solving approach that draws on skills and practices commonly used in computer science but that can be applicable to solving problems in other disciplines as well (see Dong et al., 2019). The Pack intervention consists of the Pack digital game and a set of 12 lessons that encourage students to explore different problem-solving approaches in a virtual world, as well as a professional development workshop and online community of practice for teachers that support their learning about and use of the digital game and lessons. As a result of engaging in the Pack, students are expected to develop more positive attitudes toward problem solving and increase their computational thinking skills.

During the 2022–23 school year, AIR conducted a mixed methods study to examine implementation of the Pack program and student outcomes related to their attitudes toward problem solving and their computational thinking skills. To measure teachers’ implementation and perceptions of the Pack program components, AIR administered teacher surveys, conducted teacher interviews, and collected extant program data. To measure the relationship between students’ use of the Pack and outcomes related to students’ attitudes toward problem solving and computational thinking skills, AIR administered a pre- and posttest survey of student problem solving attitudes and a computational thinking knowledge assessment. The key findings of the study are as follows:

- Teachers reported that the professional development they received from NYSCI for implementing the Pack was helpful and relevant to their teaching.
- Teachers reported that the Pack digital game and lessons were valuable for computational thinking teaching and learning.
- Teachers used the Pack as a stand-alone unit but were able to make connections to their existing curriculum units. In addition, teachers used the Pack in class, either individually or in small groups. Teachers differed in the number of the Pack lessons that they implemented in their classrooms. Teachers reported that they implemented three to 12 of the available 12 Pack lessons in their classrooms.

- Teachers perceived the Pack as a feasible program to implement, with teachers reporting that they had adequate access to technology and sufficient preparation time and administrator support to implement the Pack.
- During the study year, teachers were able to implement the Pack program components (i.e., the Pack game and lessons, professional development, and the online community of practice) with fidelity.
- There were no significant associations between students' use of the Pack and their beliefs about their ability to apply their problem-solving skills to new situations or their beliefs about their problem-solving ability as a fixed trait.
- There were no significant associations between teachers' or students' reported use of the Pack and students' scores on a computational thinking assessment. There were also no significant associations between students' reported participation in computational thinking while using the Pack and their scores on a computational thinking assessment.

Overall, the study found promising results about the feasibility and utility of implementing the Pack in middle school science and computer science classrooms. Teachers were able to implement the Pack with fidelity. Teachers also reported that the Pack professional development and digital game and lessons were helpful for computational thinking teaching and learning.

The study has a few limitations that should be considered when interpreting findings, especially those related to student outcomes. First, the AIR team conducted this study during the 2022–23 school year, which was a post–COVID-19 pandemic recovery period for schools. Teachers and students may still have been navigating the effects that the pandemic has had on teaching and learning experiences. Second, the study faced significant teacher attrition. Of the 18 teachers who attended the Pack professional development at the beginning of the study, 10 teachers implemented the Pack and participated in the data collection activities that occurred after the professional development. The student sample was also small due to active parental consent procedures and student absences during pre- and posttest data collection periods. With future investigations, the limitations in this study can be addressed and additional insights about the Pack implementation and student outcomes can emerge.

Introduction

In the Pack project (2019–2023), the New York Hall of Science (NYSCI) developed and implemented an intervention consisting of the following:

- The previously developed The Pack digital game (New York Hall of Science, 2023) through which students engage in computational thinking and scientific reasoning to solve problems in an open-world digital game with a novel environmental context
- A set of 12 lessons supporting sixth- to eighth-grade students' use of the digital game in their classrooms
- A professional development workshop and online community of practice through which students' teachers learned how to use the digital game and lessons and also supported each other in helping their students use the digital game in the lessons

The American Institutes for Research (AIR) was the project's evaluator, contributing formative findings to the Pack development between 2019 and 2022 and conducting a mixed methods evaluation of (a) the Pack intervention's classroom implementation by 10 teachers and their 84 Grade 6–8 students during the 2022–23 school year and (b) the outcomes related to the students' computational thinking skills and their attitudes toward problem solving. The students and teachers came from 10 schools across New York City. The Pack project and AIR's 2022–23 mixed methods study were conducted under an Education Innovation and Research grant (U411C190044-22) from the U.S. Department of Education. This report describes and presents findings from the mixed methods evaluation.

The Pack Intervention

The New York Hall of Science (NYSCI) developed the Pack intervention to support the integration of computational thinking teaching and learning in middle school science and computer science classrooms. The Pack intervention includes (a) the Pack digital game and set of 12 lessons that encourage students to explore different computational problem-solving approaches in a virtual world, (b) a professional development workshop for teachers, and (c) an online community of practice for teachers that supports their learning about and use of the Pack digital game and lessons.

In the Pack game, players replenish a faltering ecosystem by collecting and managing a "pack" of creatures with different functions and guiding them into appropriate sequences (algorithms) that, when carried out, achieve a desired goal (see Exhibit 1). These game mechanics lead players to practice the targeted computational thinking skills of pattern recognition, abstraction, decomposition, and algorithms (PRADA) in a playful environment (Dong et al., 2019). Through class discussions and student journals and worksheets, students are also encouraged to reflect on how they used computational thinking skills in their gameplay. As a result of engaging in the Pack, students are expected to develop positive attitudes toward problem solving and increase their computational thinking skills.

Exhibit 1. Creating an Algorithm in The Pack Game

Teachers used an NYSCI-developed teacher guide to help their students use the Pack lessons. The guide provided a detailed plan for each lesson that included the lesson purpose, lesson plan, discussion questions, and tips for differentiation based on learners' abilities. The teacher guide also included the suggested duration of each Pack lesson (one or two class periods) and sequence of lessons depending on the amount of time teachers allotted to the program (with a suggested minimum of three lessons). In addition, NYSCI provided approximately 8 hours of in-person professional development to teachers before they implemented the Pack in their classrooms. During the professional development workshop, teachers reviewed the PRADA computational thinking constructs, experienced the Pack digital game as a learner, and reflected on the structure of the supplemental lessons and the ways in which the game and lessons could be integrated into science and computer science classes. Throughout the school year, NYSCI and Participate (an online professional development provider) also facilitated an asynchronous online community of practice in which teachers were encouraged to share their experiences with implementing the Pack, upload examples of student work, and offer support to other teachers when they had questions.

During the 2022–23 school year, AIR conducted a mixed-methods study to examine implementation of these Pack program components and student outcomes related to students' attitudes toward problem solving and their computational thinking skills. This report examines implementation of the Pack program's key components, teachers' perceptions of the Pack, and outcomes of middle school students whose teachers implemented the Pack.

Study Design

During the 2022–23 school year, AIR conducted a mixed-methods descriptive study of the Pack implementation and a correlational study of student outcomes of the Pack. The study addressed five research questions (RQs) using seven data sources (Exhibit 2) that examine the implementation of the Pack, teachers' perceptions of its usefulness, and changes in student outcomes.

Exhibit 2. Research Questions and Data Sources

Research questions	Data sources
RQ1. To what extent do teachers perceive the Pack components as useful for supporting CT teaching and learning?	• Post-PD teacher survey • Post-implementation teacher survey • Teacher interview
RQ2. What are barriers and facilitators to implementation of the Pack?	• Post-implementation teacher survey • Teacher interview
RQ3. To what extent are key components of the Pack program implemented with fidelity?	• Extant teacher participation data • Post-PD teacher survey • Post-implementation teacher survey
RQ4. To what extent is use of the Pack related to students' attitudes toward problem solving?	• Student survey • Post-implementation teacher survey
RQ5. To what extent is use of the Pack related to students' CT skills?	• Student knowledge assessment • Post-implementation teacher survey

Note. CT = computational thinking; PD = professional development; RQ = research question

Program Implementation Data

To measure teachers' implementation (RQ3) and perceptions of program components (RQs 1 and 2), AIR administered teacher surveys, conducted teacher interviews, and collected extant teacher participation data.

Post–Professional Development Teacher Survey

At the conclusion of the Pack professional development workshop, AIR administered an online survey to teachers who participated in the sessions. Of the 18 participating teachers, 16 responded to the survey. The survey included 13 Likert-scale items with six response options that ranged from “strongly disagree” to “strongly agree.” The survey focused on the topics that follow. (Please see Appendix A for the post–professional development teacher survey.)

- How helpful teachers found the professional development components (three items, RQ3)
- Relevance of the professional development to computational thinking and the curricular content in teachers’ classrooms (two items, RQ1)
- Value of using the Pack (five items RQ1; adapted from Yadav et al., 2011)
- Level of confidence and self-efficacy in using the Pack (three items, RQ2; Outlier Research & Evaluation, 2017)
- General information about the participants’ instructional context (e.g., grade level, subject matter; five items)
- Open-ended questions about teachers’ professional development experience and remaining concerns about using the Pack

Post-Implementation Teacher Survey

After teachers completed their instruction with the Pack, AIR administered an online survey to teachers about their use and perceptions of the Pack. Eight of 10 teachers who implemented the Pack completed the teacher survey. The survey focused on the topics that follow. (Please see Appendix B for the post-implementation teacher survey.)

- How often teachers integrated computational thinking concepts in their classroom activities (six items, RQs 4&5)
- Level of confidence in integrating computational thinking concepts in the classroom (three items, RQ1; adapted from Outlier Research & Evaluation, 2017)
- Perceptions of the value of integrating computational thinking concepts in the classroom (four items, RQ1; adapted from Yadav et al., 2011)
- Use of the Pack (i.e., courses in which teachers used the Pack, mode of classroom instruction, the Pack lessons taught, and time spent on each Pack lesson) (four items, RQs 4&5)
- Level of confidence in using the Pack (three items, RQs 2&3; Outlier Research & Evaluation, 2017)

- Value of using the Pack (five items, RQ1; adapted from Yadav et al., 2011)
- Support teachers received to use the Pack (three items, RQ2; adapted from Outlier Research & Evaluation, 2017)

Teacher Interview

AIR conducted six interviews in spring 2023 with teachers[1] who implemented the Pack during the 2022–23 school year. Interviews were conducted virtually and lasted approximately 30–45 minutes. Interview protocol questions focused on teachers' use and perceptions of the Pack program's usefulness (RQ1) as well as perceived barriers and facilitators to implementation (RQ2). Please see Appendix C for the protocol.

Extant Teacher Participation Data

AIR requested attendance records from NYSCI staff to determine the participation of teachers in the Pack professional development workshop. AIR also collected data from the Pack online community of practice, hosted on the Participate platform. AIR collected data regarding individual teachers' participation and the types of activities offered on the online community practice.

Student Outcomes Data

To measure the relationship between teachers' and students' use of the Pack and outcomes related to students' attitudes toward problem-solving (RQ4) and computational thinking skills (RQ5), AIR administered a student survey about students' attitudes toward problem solving and a pre- and post-assessment of computational thinking skills.

Student Survey

Before and after teachers implemented the Pack, students completed a 20-minute online survey that included nine items about students' attitudes toward problem solving and 29 items about their use of the Pack. The results presented in this report include responses from 84 students across eight teachers' classrooms.

The nine survey items about students' attitudes toward problem solving focused on the topics listed below. Rasch analyses (Wright & Masters, 1982) of these items supported treating them as two separate scales; therefore, analyses were conducted using a single scale score for each construct. (Please see Appendix D for the complete survey and Exhibit E1 in Appendix E for additional details on scaling.)

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[1] Because the sample included a set of coteachers, AIR interviewed seven out 10 teachers across six interviews. In this report, we refer to *n* = six teacher interviews because there was a joint interview with the coteachers, and the two teachers expressed similar opinions.

- Students' beliefs in their ability to transfer problem solving to new scenarios (e.g., "If I want to apply a method used for solving one problem in my classes to another problem, the problems must involve very similar situations"; three items, RQ4; adapted from Dorn & Elliott Tew, 2015)
- The extent to which students endorsed a fixed mindset toward problem solving (e.g., "If I get stuck on a problem in my classes, there is no chance I'll figure it out on my own"; six items, RQ4; adapted from Dorn & Tew, 2015)

The student survey also contained 29 items about students' use of the Pack (i.e., their participation in computational thinking and approach to playing the Pack game). Please see Appendix D for these survey items.

- Students' use of the Pack (i.e., how often students played the Pack, subjects in which they used the Pack, and where they played the Pack; three items, RQs 4&5)
- How often students participated in computational thinking in their classrooms while using the Pack (e.g., developed a sequence of rules or instructions to solve a problem; six items aligned to the dimensions of the PRADA framework, RQs 4&5; adapted from Dong et al., 2019)
- Gameplay approaches students used with the Pack (e.g., find complex ways to combine creatures in a certain order to accomplish the next task; 20 items, RQs 4&5; adapted from Nacke et al., 2014)

For the 20 gameplay items, the AIR team conducted both Rasch analyses and confirmatory factor analyses to test a hypothesis that higher endorsement of specific groups of items would reflect subcategories of student gameplayer types or greater engagement with specific computational thinking constructs. These hypotheses were not supported;[2] therefore, findings related to these items are reported using only item-level descriptive statistics.

Student Knowledge Assessment

Students completed a 30-minute online computational thinking assessment before and after their teachers implemented the Pack in their classrooms. The assessment included 13 multiple-choice items from the international Bebras computational thinking competition (see Dagienė & Futschek, 2008) that most closely aligned with the PRADA constructs and did not require prior

[2] A Rasch principal component analysis of the residuals showed that the largest secondary dimension only explained 8.2% of the variance (eigenvalue = 2.28). Fit indices from a confirmatory factor analysis testing a priori categorizations did not indicate good fit (comparative fit index, 0.607; Tucker–Lewis index, 0.553; root-mean-square error of approximation, 0.134; standardized root-mean-square residual, 0.125; see Hu & Bentler, 1999).

programming knowledge from students.[3] The results presented in this report include responses from 84 students across eight teachers' classrooms.

Study Sample

NYSCI recruited teachers to participate in the study by sharing study information through their social media channels, email newsletters, and other avenues. Teachers were eligible to participate in the study if they taught science or computer science and taught at a school that served high-need students (i.e., approximately 40% or more of students faced economic need[4]) and students who are underrepresented in the STEM fields (i.e., approximately 40% or more of students are Black or Hispanic). In fall 2022, 18 teachers from 16 schools in New York City enrolled in the study and planned to implement the Pack during the 2022–23 school year. (See Appendix F for detailed information about the study's school sample.)

Of the initial 18 teachers, 10 teachers from nine schools remained enrolled in the study through the end of the school year. Teachers left the study for a variety of reasons, including maternity leave, school transfer, unexpected changes in teaching assignments, and general unresponsiveness to study requests. Any consented students from participating teachers were considered student participants in this study.[5] (See Exhibit 3 for the distribution of teachers by grade level and subject taught.)

Exhibit 3. Background Characteristics of Participating Teachers

Grade level(s) taught	Subject taught			Total
	Science	Computer science	STEM/ other subject	
Grade 6	5	2	2	**9**
Grade 7	1	0	0	**1**
Grades 7 and 8	1	0	1	**2**
Grades 6–8	2	1	2	**5**
Total	**9**	**3**	**5**	**17**

[3] Please visit the following link to view the list of items included in the student computational thinking knowledge assessment: https://drive.google.com/file/d/1fn25Cdr_LNTvUAkL9SsX1VmB144a67Pi/view?usp=drive_link

[4] The New York City Department of Education defines economic need as the average of its students' Economic Need Values. Students are considered to face economic need if they meet any of the following criteria: the student is eligible for public assistance; the student lived in temporary housing in the past 4 years; the student is in high school, has a home language other than English, and entered New York City Public Schools for the first time within the past 4 years. Otherwise, a student's Economic Need Value is based on the percentage of families (with school-age children) in the student's census tract whose income is below the poverty level, as estimated by the American Community Survey 5-year estimate.

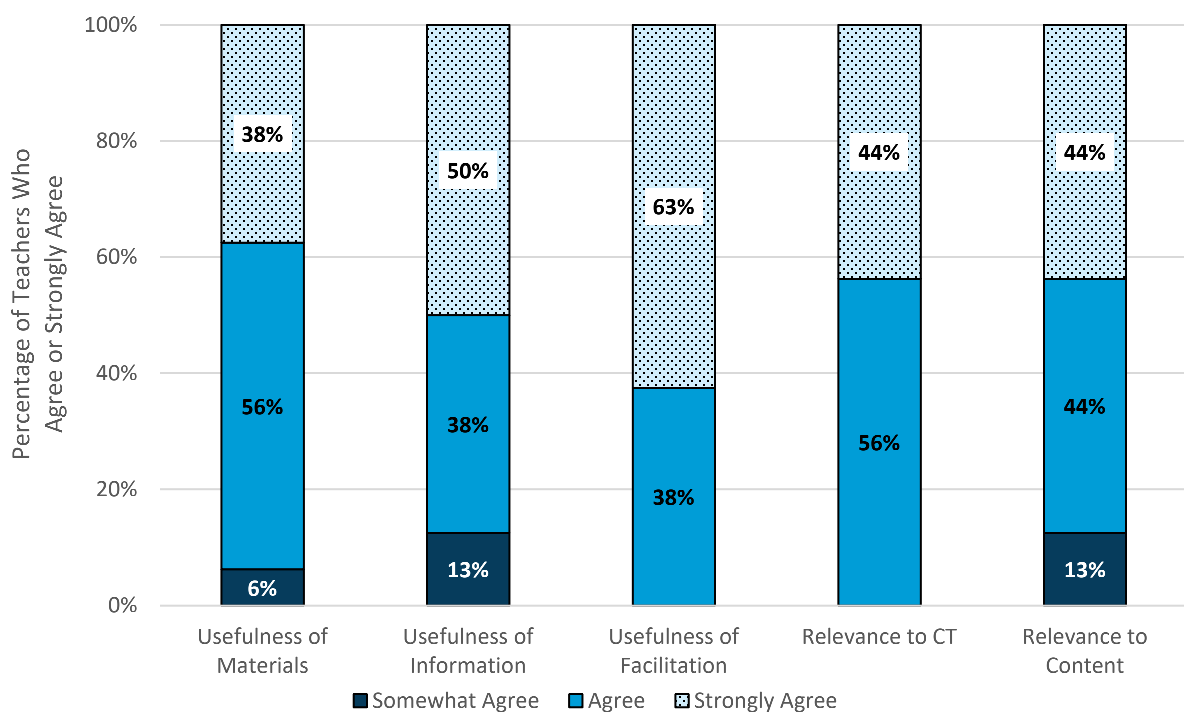
[5] AIR did not receive individual demographic information for participating students.

How do teachers participate in and perceive the Pack program supports?

This section presents findings about teachers' participation in the Pack professional development workshop and their perceptions of its usefulness (RQ1). The findings draw on teachers' responses to the post–professional development teacher survey and teacher interviews.

Surveyed teachers perceived the professional development to be helpful and relevant. To examine teachers' perceptions of the Pack professional development, teachers responded to five items on the post–professional development teacher survey about the helpfulness of the professional development materials, information, and facilitation, as well as the extent to which the content covered was relevant to teaching computational thinking and their classroom content. As shown in Exhibit 4, all 16 teacher survey participants responded that they at least somewhat agreed, agreed, or strongly agreed that professional development components were helpful and relevant to their teaching.

Exhibit 4. Teachers' Perceived Usefulness of The Pack Professional Development



Note. From post–professional development teacher survey. *N* = 16 teachers.

Teacher interview participants similarly reported that the professional development was helpful for understanding computational thinking concepts and learning how to implement the Pack. All six teacher interview participants indicated that they left NYSCI's professional development feeling encouraged and better prepared to implement the Pack. One teacher said, "The professional development gave me a much better understanding of what computational thinking is … And that helped me figure out what areas I could put it into for the school year." Another teacher did not have much gaming experience and stated that professional development "made you feel at least confident enough. So even though you weren't a gamer, you were like 'Okay, we can do this.'"

Most interviewed teachers identified areas in which the professional development could be improved. Four out of the six interviewed teachers provided suggestions for how NYSCI could improve the professional development. Some suggestions are as follows:

- One teacher provided a general suggestion to NYSCI about having more in-person trainings throughout the year.
- One teacher recommended that NYSCI offer another professional development workshop later in the year as a refresher on how to integrate the Pack and computational thinking in their individual curriculums.
- One teacher recommended that NYSCI offer a training to students on-site at their schools, particularly about the purposes of the Pack lessons.

How do teachers and students use the Pack game and lessons?

This section presents findings about teachers' use of the Pack as well as barriers and facilitators to implementation (RQ2). In addition, AIR provides findings about students' approaches to playing the Pack game and the extent to which they engage in computational thinking activities while playing the Pack. The findings draw on responses to the post-implementation teacher survey, teacher interviews, and student survey.

Teachers' Use of The Pack in Classrooms

This section presents findings about how teachers implemented the Pack game and lessons in their classrooms. During teacher interviews, AIR asked teachers to describe how they integrated the Pack into their curriculum and how they instructed students to use the Pack game and lessons. AIR also surveyed teachers about the specific Pack lessons they used in their classroom. The findings draw on six teacher interviews and eight teacher responses to a post-implementation teacher survey.

Interviewed teachers used the Pack as a stand-alone unit but were able to make connections to their existing curriculum units. All six interviewed teachers reported that they used the Pack as a stand-alone unit but also noted that the Pack connected with what students learned prior to or while using the game. For example, one teacher said "I would say it had to be a stand-alone because when we did populations and resources, it was at a different time then when we had the iPads in order to implement. But it connected." Another teacher stated that "[The Pack] was actually a good foundation to analyze the engineering unit problems."

The six interviewed teachers reported that students used the Pack in class, either individually or in small groups, with one saying that students also used it at home. Five out of six interviewed teachers reported that their students used the Pack in class only. The sixth teacher said that students used the Pack both in class and at home. This teacher said, "At the end, the kids got excited so I gave them [the Microsoft link] too so that they could continue playing when the program was over with." The classroom arrangement for using the Pack varied across teachers. Three of the six teachers reported that students played the Pack individually on their devices. Two teachers noted that they used both individual and small-group arrangements so that the students could "work together [and] brainstorm together." One of the six teachers reported that students only played the Pack in small groups. Of the four interviewed teachers asked how much time their students used the Pack, three teachers said between 11 and 15 hours total, and one said that they used the Pack for 5 hours.

Surveyed teachers varied in the number of the Pack lessons they used in their classroom. Teachers reported that they implemented three to 12 of the available 12 Pack lessons in their classrooms (see Exhibit 5). All eight surveyed teachers reported using the "Game Journal" lesson, which introduces students to the Pack gameplay and offers opportunities for students to reflect on computational thinking and generate a class-level list of tips and tricks for playing the Pack. Seven of eight surveyed teachers implemented the "Seed Trio" lesson, which targets the computational thinking concepts of decomposition and abstraction. Six teachers used "Level Up," in which students design a new level of the Pack in order to reflect on and synthesize their experiences from gameplay.

Exhibit 5. The Pack Lessons Taught by Each Teacher

Lessons	Teachers								Total teachers
	A	B	C	D	E	F	G	H	
Game Journal Parts 1 and 2	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	8
Three of a Kind	⊙	⊙	⊙			⊙	⊙	⊙	6
Level Up	⊙	⊙	⊙	⊙		⊙			5

Lessons	Teachers								Total teachers
	A	B	C	D	E	F	G	H	
Remixing It Up	●	●	●		●				**4**
Seed Trio	●	●	●	●	●	●		●	**7**
Make & Break It	●		●						**2**
Who Put That There?	●		●	●					**3**
How'd He Do It?	●			●					**2**
Making It Work	●	●	●		●		●		**5**
Stay Hydrated	●	●		●	●	●			**5**
Dropper Food Dash	●	●							**2**
Map Gaps	●	●		●					**3**
Total Lessons	**12**	**9**	**8**	**7**	**5**	**5**	**3**	**3**	

Teachers' Perceived Facilitators, Barriers, and Challenges to Use of The Pack

This section presents findings about teachers' perceived facilitators, barriers, and challenges to using the Pack game and lessons in their classrooms. The findings draw on eight teacher responses to a post-implementation teacher survey and six teacher interviews.

All surveyed teachers reported having adequate access to technology, and six of eight teachers reported having sufficient preparation time and administrator support to implement the Pack. Eight teachers responded to three items on the post-implementation teacher survey about the barriers and supports they experienced when implementing the Pack. Overall, most teachers felt supported by their administration to implement the Pack, felt that they had access to the necessary technology to participate, and had time to prepare to implement the Pack. However, two of eight teachers disagreed that they felt adequately supported by administration, and one teacher disagreed that they had enough time to prepare to implement the Pack.

Teachers experienced different challenges in implementing the Pack, such as the difficulty level of the game and lessons.

- Two of six interviewed teachers identified the difficulty of the Pack game as a challenge. One of these teachers mentioned that many of their students struggled, saying "it took [students] maybe four periods to find a seed, and then they're being asked to take a look at four other people's plans and come up with a new plan. So that was very challenging for a lot of students." The other teacher said that several students struggled with the game.

- One teacher found the vocabulary used in the Pack (i.e., “deconstruct” and “decompose”) to be too difficult for their students to understand.
- One teacher described challenges students had connecting the Pack back to the lesson worksheets. They said, “By looking at the worksheet, it feels like they don’t seem to grasp the idea of that concept. Even though they did it, they played the game, they solved the problem, they cannot translate that into their written expression.”
- One teacher reported challenges regarding time to implement the game and to help the students move along in the game.
- One teacher reported technical issues with students not saving their work or overriding other students’ progress in the game.

Students’ Use of The Pack in Classrooms

This section presents findings about students’ use of the Pack in the classroom, including the extent to which they reported participating in computational thinking in their classrooms while using the Pack and their approaches to playing the Pack game. The findings draw on 84 responses to the student survey.

Participation in Computational Thinking While Playing The Pack

Students responded to six items about the frequency with which they participated in computational thinking (i.e., pattern recognition, abstraction, decomposition, debugging, and algorithmic thinking) in their classroom. The number of responses to each item ranged from N = 80 to N = 84 students. Overall, there were no significant differences between the pre- and the posttest surveys in the proportion of students who reported doing computational thinking in their classroom at least once or twice a week. A majority of students (60%–80%) reported participating in computational thinking at least once or twice a week prior to using the Pack, and a majority also reported participating in computational thinking at least once or twice a week after using the Pack (57%–72%).

Gameplay Behaviors While Playing The Pack

On the posttest student survey, students completed 20 items asking them to rate the extent to which certain behaviors within the game described how they played the Pack game. As described previously in the discussion of methods, Rasch analyses and confirmatory factor analyses did not support hypothesized subscales for this set of items. The three items with the highest percentage of students rating “very much so” to describe how they played the game were the following:

- “When I encounter a seed I can’t get to, I start by thinking of how the creatures in my Pack can be combined to help me reach it.” (48% of students)

- “If I can’t get to an area from one direction, I look to see if there are alternative paths to get there.” (46% of students)
- “When I encounter a seed I can’t get to, I start by thinking of how I need to change the environment to get to it.” (45% of students)

The three items with the lowest percentage of students rating “very much so” to describe how they played the game were the following:

- “I leave creatures in areas on the map where they tend to be most useful and then come back for them when I need them.” (15% of students)
- “Even if one algorithm works, I’ll try to make another one that does the task in a better way.” (22% of students)
- “I plan out how many spaces I would need to dig to get water to reach dry areas.” (26% of students)

See Exhibit E2 in Appendix E for responses to the full set of items.

To what extent do teachers perceive the Pack game and curriculum as useful for supporting computational thinking teaching and learning?

This section presents findings about teachers’ perceptions of the usefulness of the Pack digital game and curriculum (RQ1). The findings draw on 16 teacher responses to the post–professional development teacher survey, eight teacher responses to the post-implementation teacher survey, and six teacher interviews.

Surveyed teachers perceived the Pack to be valuable. The five items measuring the value of the Pack were scaled using the Rasch model and showed good reliability for a single-factor scale (see Appendix E for additional information on scaling). The teachers had mean scale scores of 3.1 (SD = 0.34) and 3.0 (SD = 0.34), respectively, on a 4-point scale for their ratings of the five survey items about the value of the Pack on the post-professional development and post-implementation teacher surveys. These scores indicate agreement with the five statements about the value of the Pack (see Question 10 in the post-implementation teacher survey in Appendix B).

Some interviewed teachers reported that worksheet and lesson plan templates for teachers were useful aspects of the Pack game and lessons. Two of the six interviewed teachers found the worksheet and lesson plan templates to be helpful, with one teacher saying, “From a teacher’s perspective, it is definitely the lesson plans being provided [that] is extremely helpful. … I would say it’s already a high-quality product, which I can just use as is. Very often that thing is the most helpful.” However, one teacher indicated that more support for differentiation would be helpful, saying, “We have a lot of [students with disabilities]. So, there were a lot of components that we didn’t do. We just kept to two or three things. And so, we modified it basically to meet their needs.”

Interviewed teachers indicated that the Pack was useful for student learning of computational thinking concepts. Teachers described aspects of the Pack game and lessons that were most useful for student learning, such as student journals, the Pack game, and the Pack’s focus on computational thinking concepts:

- Three of the six interviewed teachers reported that the student journal was one of the most useful aspects of the Pack. Students completed the student journals as part of the Game Journal lesson. Students used the journals to document their gameplay approaches, identify challenges they encountered, and reflect on computational thinking concepts. One teacher said, “Just stopping to think about [the Pack] and write about it helps [the students] process.”
- Two teachers said that the Pack game itself was most useful for students’ learning of computational thinking. However, three teachers mentioned either the difficulty levels of the game being too advanced or a recommendation to add more game levels.
- Another teacher pointed out that the Pack’s focus on computational thinking terminology was useful for students across subjects, not just science. They said, “We went in [another teacher’s math class] and I saw ‘algorithm’ on the board, and [the teacher] was asking them what the definition was, and nobody was raising their hands … I said, ‘Okay, everybody, what is the algorithm for the Pack?’ and then all of a sudden all the hands were going up. ‘Oh, it’s the friends. Oh, it’s the friends working together.’… So, this is what we’re talking about, all the components working together.”

Furthermore, all six interviewed teachers reported that they had observed ways in which the Pack supported student learning. Teachers shared examples of students demonstrating problem-solving abilities, learning how to code, learning about environments, and collaborating with peers. One teacher described how the Pack encouraged students to reflect on their thinking, saying,

> “[With the Amplify curriculum], what I decided to do was ask our students, ‘After you’ve read this article, you’ve looked at the video, you’ve done a few more activities, let’s go back to the Write and Share. How might you change your answer now?’ Usually, students will either turn in their same exact answer, or they will write down the key

concept note that matches what the ‘right answer’ would be. What I saw with [my class] after they had worked on the Pack was their answers were, ‘Before working on the video, I thought this. I thought this because X, Y, and Z. Now I understand this, and the reason I understand this is because ...’ This was organic. This was me, and my 12-year-old self [being able to recognize] how I can build upon what I already thought, and that was new. That was new for me as an educator.”

To what extent are key components of the Pack implemented with fidelity?

This section presents findings about implementation fidelity (RQ3) for each key component of the Pack program: the Pack digital game and 12 lessons, the teacher professional development workshop, and the online community of practice. For each component, the NYSCI project team identified implementation indicators and criteria for fidelity of implementation. The paragraphs that follow describe the indicators for fidelity of implementation for each component and summarize the findings. For the most part, program implementation met the criteria for implementation fidelity.

The Pack Digital Game and 12 Lessons

Four of the five indicators for the Pack game and lessons were met. Data were not collected for the fifth indicator.

1. **Teachers value the Pack.** Based on responses to the post-implementation teacher survey, 87.5% of teachers reported valuing the Pack, meeting the criterion for implementation fidelity of at least 75% of teachers.
2. **Teachers are confident in their ability to use the Pack.** Based on responses to the post-implementation teacher survey, at least 87.5% of teachers reported feeling confident in using the Pack on all three relevant survey items, meeting the criterion of at least 75% of teachers.
3. **Teachers use the Pack in their classroom.** Based on responses to the post-implementation teacher survey, 100% of teachers who responded to the survey used at least three Pack lessons, meeting the criterion of at least 75% of teachers.
4. **Teachers receive adequate support to implement the Pack.** Based on responses to the post-implementation teacher survey, 75% of teachers reported having adequate supports for Pack implementation on all three relevant survey items, meeting the criterion of at least 75% of teachers.

5. **Students reach at least Level 2 in the Pack digital game.** The criterion for implementation fidelity is for at least 75% of students to reach at least Level 2 in the Pack digital game. This criterion was intended to be measured using student achievement logs that detailed students' progress in the Pack digital game. However, the AIR team did not receive the student achievement log data.

Professional Development Workshop

The teacher professional development workshop had two implementation fidelity indicators, both of which were met.

1. **Teachers attend professional development.** Based on attendance data from NYSCI, 100% of teachers attended both days of the professional development workshop or the makeup session, meeting the implementation fidelity criterion of at least 75% of teachers attending both days.
2. **Teachers are satisfied with the professional development.** Based on responses to the post–professional development teacher survey, 100% of teachers reported satisfaction with the professional development, meeting the criterion of 75% of teachers.

Online Community of Practice

The online community of practice had two implementation fidelity indicators, both of which were met.

1. **Teachers participate in the online community of practice.** Based on teacher usage records from the online community of practice on Participate, 100% of teachers participated in the online community of practice (i.e., signed into the community of practice at least once), meeting the criterion of 75% of teachers.
2. **Teachers are provided at least one activity in each of the community-of-practice categories.** Based on records from the online community of practice, NYSCI and Participate offered teachers one to three activities in each of the community-of-practice categories, meeting the criterion of at least one activity in each category.

Exhibit 6 provides a summary of fidelity of implementation for each of the components.

Exhibit 6. Fidelity of Implementation Results

Indicator	Data source	Criterion	Actual implementation	Met?
		The Pack Digital Game and Lessons		
Teachers value the Pack	Post-implementation teacher survey	At least 75% of teachers value including the Pack in their classes	87.5% of teachers reported valuing the inclusion of the Pack in their class	Met
Teachers are confident in their ability to use the Pack	Post-implementation teacher survey	At least 75% of teachers are confident in their ability to use the Pack in their classes	87.5% of teachers reported feeling confident in their ability to use the Pack in their classes on all three survey items	Met
Teachers use the Pack in their classroom	Post-implementation teacher survey	At least 75% of teachers use at least three Pack lessons in their class	100% of teachers used at least three Pack lessons in their class	Met
Teachers receive adequate support to implement the Pack	Post-implementation teacher survey	At least 75% of teachers report receiving adequate support to implement the Pack	75% of teachers reported receiving adequate support to implement the Pack on all three survey items	Met
Students reach at least Level 2 in the Pack digital game	Achievement log	At least 75% of students reach at least Level 2 in the Pack game	No data	No data
		Teacher Professional Development Workshop		
Teachers attend professional development	Teacher professional development attendance records	At least 75% of teachers attend the Pack professional development	100% of teachers attended the Pack professional development	Met
Teachers are satisfied with professional development	Post–professional development teacher survey	At least 75% of teachers report satisfaction with the Pack professional development	100% of teachers reported satisfaction with the Pack professional development	Met
		Online Community of Practice		
Teachers participate in CoP	CoP records	At least 75% of teachers participate in CoP	100% of teachers participated in the CoP	Met
Teachers are provided one CoP activity in each category	CoP records	Teachers are provided at least one CoP activity from each category	Teachers were provided one to three CoP activities from each category	Met

Note. CoP = community of practice

To what extent is use of the Pack related to student outcomes?

This section presents findings about the extent to which teacher and student use of the Pack was related to students' attitudes toward problem solving (RQ4) and students' computational thinking skills (RQ5). Students' use of the Pack was measured by their responses to a single survey item about the number of times they used the Pack in their class that year. For teachers, use of the Pack was measured using their response to an item on the teacher survey asking the number of hours spent teaching each of the Pack lessons. These responses were combined into a single count of the total lessons that a teacher had indicated teaching in their class for any amount of time (e.g., any response other than "I did not teach this lesson in my class."). The findings draw on the 84 student responses to the student survey and the pre- and post-assessment of computational thinking.

Student Attitudes Toward Problem Solving

To examine whether student use of the Pack was associated with students' attitudes toward problem solving (RQ4), the AIR team conducted regression analyses of students' use of the Pack on the Rasch scale scores for their ability to apply problem-solving skill to new situations and their beliefs that their problem-solving ability was a fixed trait. Results showed no significant association between students' use of the Pack and their scale score for either student beliefs about their ability to apply their problem-solving skills to new situations ($B = 0.28$, p=.171) or student beliefs about problem-solving ability as a fixed trait ($B = 0.21$, $p = .138$). See Exhibit E3 in Appendix E for the full regression results.

Student Computational Thinking Skills

To examine whether student and teacher use of the Pack was associated with increases in students' computational thinking skills (RQ5), AIR conducted regression analyses of students' raw scores (i.e., percentage correct) on the computational thinking assessment on both teacher and student measures of use of the Pack, controlling for their pretest scores. Overall, neither the teacher nor the student indicators of the extent of their use of the Pack were significantly correlated with students' scores on the computational thinking assessment ($B = 0.013$, $p = .873$ and $B = 0.062$, $p = .457$, respectively). See Exhibit E4 in Appendix E for the full regression results.

Finally, the AIR team examined the association between the extent to which students said that they participated in computational thinking and their raw scores on the computational thinking assessment. We measured participation in computational thinking with six items from the student, each of which aligned with a dimension of the PRADA framework. AIR found that there were no significant associations between each of the item scores and computational thinking assessment scores. See Exhibit E4 in Appendix E for the complete regression results.

Summary and Conclusions

Based on the findings in this report, AIR shares the following summary of findings and conclusions.

Summary of Findings

Teachers reported that the professional development they received from NYSCI for implementing the Pack was helpful and relevant to their teaching. In response to the post–professional development teacher survey, all teacher survey participants reported that they at least somewhat agreed, agreed, or strongly agreed that professional development components were helpful and relevant to their teaching. In addition, all teacher interview participants similarly indicated that they left NYSCI's professional development feeling encouraged and better prepared to implement the Pack. Some teacher interview participants also suggested that NYSCI provide more professional development throughout the year as a refresher for teachers on the Pack and computational thinking.

Teachers reported that the Pack digital game and lessons were valuable for computational thinking teaching and learning. Based on responses to the post-implementation teacher survey, AIR found that all surveyed teachers agreed or strongly agreed that the Pack was valuable. Interviewed teachers similarly reported that the Pack was useful, noting the helpfulness of worksheet and lesson plan templates and the Pack game and lessons in teaching computational thinking concepts. Interviewed teachers also shared examples of student learning after engaging with the Pack game and lessons, saying that students demonstrated problem-solving abilities, learned how to code, learned about environments, and collaborated with peers.

Teachers used the Pack as a stand-alone unit but were able to make connections to their existing curriculum units. Interviewed teachers reported that they used the Pack as a stand-alone unit but also noted that they connected the Pack with what students learned prior to or while using the game (e.g., environmental science, engineering). In their responses, teachers provided additional information about the ways in which they implemented the Pack. Five out of six interviewed teachers reported that their students used the Pack in class only. Teachers reported that students used the Pack individually, in small-group arrangements, or both. Finally, teachers reported that they implemented three to 12 of the available 12 lessons in the Pack in their classrooms.

Teachers perceived the Pack as a feasible program to implement, with teachers reporting that they had adequate access to technology and sufficient preparation time and administrator

support to implement the Pack. Based on responses to the post-implementation teacher survey, AIR found that most surveyed teachers felt supported by their administration to implement the Pack, felt that they had access to the necessary technology to participate, and had time to prepare to implement the Pack. Only two of the eight surveyed teachers disagreed that they felt adequately supported by administration, and one teacher disagreed that they had enough time to prepare to implement the Pack.

During the study year, teachers were able to implement the Pack program components (i.e., the Pack game and lessons, professional development, and online community of practice) with fidelity. Using teacher survey and extant data sources, the AIR team examined nine indicators of implementation fidelity across the three key components of the Pack: the Pack game and 12 lessons, teacher professional development workshop, and online community of practice. The implementation fidelity indicators for all components were met except for one indicator for which the data to be used were not collected.

There were no significant associations between students' use of the Pack and their beliefs about their ability to apply their problem-solving skills to new situations or their beliefs about problem-solving ability as a fixed trait. Regression analyses did not find significant associations between students' use of the Pack and their scale scores for either their beliefs about their ability to apply their problem-solving skills to new situations or their beliefs about problem-solving ability as a fixed trait.

There were no significant associations between student's use of the Pack and their scores on a computational thinking assessment. There also were no significant associations between student's self-reported participation in computational thinking while using the Pack and their scores on the computational thinking assessment. Regression analyses did not find significant association between use of the Pack or self-reported participation in computational thinking and scores on the computational thinking assessment.

Conclusions

The study yields promising results related to teachers' implementation and perceptions of the Pack. The implementation fidelity results suggest that teachers are able to implement the key components of the Pack program as designed. Furthermore, surveyed and interviewed teachers indicated that the Pack game and lessons are feasible to implement, with teachers reporting that they had adequate technology, administrator support, and preparation time to implement the Pack in their classrooms. In addition, teachers perceived the Pack professional development and the game and lessons to be valuable to computational thinking teaching and learning. Teachers also reported that they have observed examples of student learning that they can attribute to the Pack. In sum, these findings indicate that teachers deem the Pack a feasible and valuable program for integrating computational thinking concepts in middle school classrooms.

AIR notes the following limitations that should be considered when interpreting the findings in this report and the lack of significant findings related to student outcomes: First, the study faced significant teacher attrition as well as small numbers of students participating in data collection activities. Of the 18 teachers who attended the Pack professional development at the beginning of the study, 10 teachers implemented the Pack and participated in the data collection activities that occurred after the professional development. Teachers left the study for a variety of reasons, including maternity leave, school transfer, unexpected changes in teaching assignments, and general unresponsiveness to study requests. Second, the study occurred during the 2022–23 school year, which was a post–COVID-19 pandemic recovery period for schools. Teachers and students may have still been navigating the effects that the pandemic has had on teaching and learning experiences, which could have contributed to low participation in the study. With future investigations, the limitations in this study can be addressed and additional insights about the Pack implementation and student outcomes can emerge.

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Appendix A. Post–Professional Development Teacher Survey

How much do you agree with these statements about the PD workshop? (Response options: Strongly disagree, Disagree, Slightly disagree, Slightly agree, Agree, Strongly agree)

1. The materials provided in the workshop (e.g., challenge worksheets, teacher guides) were helpful in preparing me to implement the Pack in my classroom.
2. The information presented in the workshop (e.g., presentation slides) was helpful in preparing me to implement the Pack in my classroom.
3. The way that the workshop was facilitated was helpful in preparing me to implement the Pack in my classroom.
4. The workshop as a whole was relevant to teaching computational thinking concepts.
5. The workshop as a whole was relevant to my course content.

How much do you agree with these statements about using the Pack? (Response options: Strongly disagree, Disagree, Slightly disagree, Slightly agree, Agree, Strongly agree)

6. I am excited to use the Pack in my classroom.
7. Using the Pack will help me to develop students' understanding of key concepts in my classroom.
8. Using the Pack will help me to develop students' approach to solving problems in my classroom.
9. I would have to give up a lot of other important content in order to implement the Pack in my classroom.
10. Using the Pack in my classroom will require too much effort.
11. I am confident I can use the Pack in my classroom.
12. I believe I can be successful using the Pack in my classroom.
13. I know that I can effectively implement the Pack in my classroom.

The below short-answer responses will help us improve the Pack.

14. What are your concerns at this point about using the Pack to integrate CT into your classroom?
15. What components of the workshop did you find most effective in preparing you to implement the Pack?
16. What were some aspects of implementing the Pack in your classroom that you wish had been covered in more depth during the workshop?

These questions will help us to support you as you use the Pack.

17. What grade level do you teach (select all that apply)?
    a. 5th
    b. 6th
    c. 7th
    d. 8th
18. What course will you be teaching with the Pack (select all that apply)?
    a. Mathematics
    b. English
    c. Science
    d. Social Studies
    e. Computer Science
    f. Other (write in)
19. How would you describe your level of experience with computing?
    a. No experience
    b. Very little experience
    c. Quite a bit of experience
    d. A great deal of experience
20. How many students are currently enrolled in your class?
21. When (approximately) do you plan to start to teach Computational Thinking with your students?

Appendix B. Post-Implementation Teacher Survey

Section 1: The following questions are about the integration of computational thinking in your class this year.

1. How often did you incorporate the concepts of Computational Thinking from the NYC standards into your classroom activities this year?
   a. I did not teach this in my classroom this year
   b. Once or twice ever
   c. Once or twice a month
   d. Once or twice a week
   e. Nearly every day
2. How often did you ask students to do the following in your classroom? (Response options: We didn't do this in my classroom this year, Once or twice ever, Once or twice a month, Once or twice a week, Nearly every day)
   a. Break down a larger problem into smaller parts
   b. Find patterns in smaller problems to help solve larger problems
   c. Revise solutions so that they can be used to solve other problems
   d. Develop a sequence of rules or instructions to perform a task or solve a problem
   e. Make changes to your solution so that it works better or more efficiently

The following questions ask about your *confidence* integrating computational thinking in your classes this year.

3. How much do you agree or disagree with the following statements? (Response options: Strongly disagree, Disagree, Agree, Strongly agree)
   a. I understand computational thinking concepts well enough to integrate them into my lessons.
   b. I have nearly every skill I need to integrate computational thinking concepts when teaching my class.
   c. I will be really good at using computational thinking concepts when I teach my class.

The following questions ask about your perception of the *value* of computational thinking in your content area.

4. How much do you agree or disagree with the following statements? (Response options: Strongly disagree, Disagree, Agree, Strongly agree)
    a. Computational thinking can be integrated into classroom education in my content area.
    b. Computational thinking should be integrated into classroom education for my content area.
    c. Having background knowledge and understanding of computational thinking will help students gain a better understanding of key concepts in my content area.
    d. Having background knowledge and understanding of computational thinking will help students with problem solving.

Section 2: The following questions are about your use of the Pack in your classroom this year.

5. Did you implement the Pack in your classroom this year?
    a. Yes
    b. No (***if selected, skip to #16***)

6. Which subjects did you use the Pack with? (select all that apply)
    a. Science
    b. Computer science
    c. Math
    d. English language arts
    e. Social studies
    f. World languages
    g. Career and technical education
    h. Arts
    i. Physical education
    j. Afterschool program

7. In what learning environment were the majority of your lessons delivered?
    a. In Person
    b. Remote
    c. Blended/Hybrid

8. Indicate about how much time you assigned students to spend on each Pack lesson below. (Response options: I did not use this lesson in my class, 1 min–1 hour, 1–2 hours, 3–4 hours, 4+ hours)
    a. Game Journals (Parts 1 and 2)
    b. 3 of a Kind
    c. Making it Work
    d. Remixing It Up
    e. Seed Trio
    f. Who Put That There?
    g. Make & Break It
    h. Stay Hydrated
    i. Dropper Food Dash
    j. How'd He Do It?
    k. Map Gaps
    l. Level Up

9. What did you typically ask students to do when completing the lessons above? (check all that apply)
    a. Complete the lesson worksheet
    b. Participate in group discussion (virtual or in person) about their work on the lesson
    c. Participate in a meeting (virtual or in person) with the teacher to discuss their work on the lesson
    d. Students worked independently on playing the game at home or at school
    e. Students worked with others to play the game at home or at school
    f. Students shared work samples from the game (e.g., images of algorithms they made) and discussed with other students
    g. Students had the chance to apply the concepts and skills developed in the lesson to some other part of your curriculum
    h. Hard to know what they did—assigned lessons but didn't get work back from them
    i. Other (write in):

The following questions ask about your *experiences* teaching with the Pack.

10. How much do you agree or disagree with the following statements? (Response options: Strongly disagree, Disagree, Agree, Strongly agree)
    a. I am excited to continue to use the Pack in my classroom.
    b. Using the Pack helped me to develop students' understanding of key concepts in my classroom.
    c. Using the Pack helped me to develop students' approach to solving problems in my classroom.
    d. I had to give up a lot of other important content in order to implement the Pack in my classroom.
    e. Using the Pack in my classroom required too much effort.

The following questions ask about your *confidence* in using the Pack in your class.

11. How much do you agree or disagree with the following statements? (Response options: Strongly disagree, Disagree, Agree, Strongly agree)
    a. I am confident I could use the Pack in my classroom.
    b. I believe I can be successful using the Pack in my classroom.
    c. I know that I can effectively implement the Pack in my classroom.

The following questions ask about the *support* you received in implementing the Pack.

12. How much do you agree or disagree with the following statements? (Response options: Strongly disagree, Disagree, Agree, Strongly agree)
    a. I felt sufficiently supported by my school administration to implement the Pack effectively.
    b. I had access to all of the technology I need to implement the Pack effectively.
    c. I had enough time to prepare for implementing the Pack into my lessons.
13. What are your concerns at this point about using the Pack in your classroom?
14. What did you find most effective about the Pack? How could The Pack be improved?
15. In what ways did teaching with the Pack build on what you already did in your classroom?
16. If you did not implement the Pack this year, please explain why you did not.

Appendix C. Teacher Interview Protocol

First, we would like to know a little about you and your teaching experience.

1. What subjects and grade levels do you teach?
2. How many years have you been a teacher? How many years have you taught at this school?
3. How many years have you taught science or computer science? How many years have you taught science or computer science at this school?

The Pack program offers teachers the digital game and curriculum, professional development from NYSCI, and an online community of practice.

4. What was your first impression of the Pack?
5. Overall, what components of the Pack program do you think were most helpful to you as a teacher? Which components were less helpful? [Probe for: the Pack game and curriculum, professional development workshops, and online CoP]

Next, we will ask you a few questions about each of the components of the Pack program. First, we will start with NYSCI's professional development workshops that you attended about the Pack.

6. What types of professional development about the Pack game and curriculum did you receive from NYSCI? [Probe about whether these topics were covered: Introduction to Computational Thinking (CT), Gameplay with The Pack, Integrating The Pack into Instruction]
7. Do you feel that the professional development helped you implement the Pack game and curriculum? Why or why not?
8. What advice, if any, would you give to NYSCI about how they could improve the professional development that they provide to teachers about the Pack game and curriculum?

Now, we would like to hear about your experience using the Pack game and curriculum in your classroom.

9. Why did you decide to use the Pack?
10. How did you introduce the Pack to your students?
    a. Probe: How did you explain the purpose of the Pack to students?
    b. Probe: How did students react to learning they would play the Pack?
11. How many hours would you estimate that your students played the Pack?
12. Did you integrate the Pack into your existing science or computer science instructional materials, or did you use stand-alone lessons that featured the Pack?
13. How, if at all, did you use the Pack to make connections to your existing science or computer science curriculum?
14. Were there specific aspects of the Pack game or curriculum that you found most useful? Least useful?
15. When did you and your students use the Pack? During class time? As homework? Both?
16. Did students play the Pack individually, in small groups, or as a whole class? Why did you select that arrangement?
    a. Probe: Would you recommend using the Pack in that arrangement? Why or why not?
17. To what extent were students engaged while playing the Pack?
    a. Probe: How did you know they were engaged?
18. When your students played the Pack, what do you think they were learning? How did you know they were learning?
19. What challenges did you or your students experience when engaging with the Pack?
20. Overall, what advice, if any, would you give to NYSCI about how they could improve the Pack game and curriculum for students and teachers?

Next, we have a few questions about the online community of practice that was hosted on the Participate platform.

21. Did you engage with Participate's online community of practice? If so, how?
    a. Probe: If you didn't participate in the online community of practice, can you please explain why you did not participate?
22. In what ways, if any, did the online community of practice support your learning of the Pack game and curriculum and how to use it in your instruction?
    a. Probe: In what ways, if any, were you able to share strategies for using the Pack with other teachers?
    b. Probe: In what ways, if any, were you able to troubleshoot challenges with implementing the Pack?
23. How do you think the online community of practice could be improved?

Is there anything else you'd like to share about the Pack that hasn't been covered?

Appendix D. Student Survey

Section 1: The following questions ask about your use of the Pack game this year.

1. Which of the following options best describes how often you played the Pack this school year?
    a. I didn't play the Pack this year ***(If selected, skip to #5)***
    b. Once or twice ever
    c. Once or twice a month
    d. Once or twice a week
    e. Nearly every day

2. When did you use the Pack this year? (select all that apply)
    a. At home
    b. At school, during class time
    c. At school, during free time

3. Which classes did you use the Pack with? (select all that apply)
    a. Science
    b. Computer science
    g. Math
    h. English language arts
    i. Social studies
    h. World languages
    i. Career and technical education
    j. Arts
    k. Physical education
    l. Afterschool program

4. To what extent do the following statements describe how you played the Pack? (Response options: Not at all, A little, Somewhat, Very much so)

    a. I try to see how far into the desert I can take my avatar before the water drop gets too big and I get sent back on the map.
    b. I try to dig or build in ways that cost as little fruit as possible so I don't have to waste time collecting fruit.
    c. I use my pack to find fruit for me instead of looking for fruit with my avatar.
    d. I use the repeater so that my algorithms use less fruit.
    e. I leave creatures in areas on the map where they tend to be most useful and then come back for them when I need them.
    f. I use the map to locate water so that I can dig a canal in the right direction, toward a seed on dry land.
    g. I use parts of the same algorithm to get food in different ways (e.g. from underground, or from a tree)
    h. I create general algorithms that I can change slightly to accomplish different tasks.
    i. I wander around the map to locate as many seeds as I can before I start collecting them.
    j. I collect a lot of food of different types before I start using it to collect seeds.
    k. When I encounter a seed I can't get to, I start by thinking of how I need to change the environment to get to it.
    l. When I encounter a seed I can't get to, I start by thinking of how the creatures in my Pack can be combined to help me reach it.
    m. If I can't get to an area from one direction, I look to see if there are alternative paths to get there.
    n. I will usually try to dig or build something first, see if it works or not, and then adjust.
    o. Before trying an algorithm, I will test it and make changes until it does what I want.
    p. Even if one algorithm works, I'll try to make another one that does the task in a better way.
    q. I decide where I should go and what I should do next based on where on the map I haven't explored yet.
    r. I plan out how many spaces I would need to dig to get water to reach dry areas.
    s. I think about the steps needed to change the environment in different ways.
    t. I find complex ways to combine creatures in a certain order to accomplish the next task.

Section 2: The following questions ask about problem solving in your classes this year.

5. Which of the following options best describes how often you worked on the following activities in your class this semester? (Response options: We didn't work on that this year, Once or twice ever, Once or twice a month, Once or twice a week, Nearly every day)
    a. Breaking a problem down into smaller parts
    b. Finding patterns in smaller problems that help you solve bigger problems
    c. Revise a prior solution to use for another problem
    d. Identify and remove unnecessary details to make a solution apply to more than one problem
    e. Develop a sequence of rules or instructions to perform a task or solve a problem
    f. Make changes to a solution to make it work better or more efficiently

6. When solving a problem in this class ... (Response options: Strongly disagree, Somewhat disagree, Not sure, Somewhat agree, Strongly agree)
    a. I create a list of steps to solve it
    b. I use math.
    c. I try to simplify the problem by ignoring details that are not needed
    d. I look for patterns in the problem
    e. I break the problem into smaller parts
    f. I work with others to solve different parts of the problem at the same time
    g. I look how information can be collected, stored, and analyzed to help solve the problem
    h. I create a solution where steps can be repeated
    i. I create a solution where some steps are done only in certain situations
    j. I assess each stage separately when solving a problem
    k. If I run into a problem when trying to find a solution, I review the stage at which I encountered the problem instead of starting over
    l. I can determine what to do step by step when I am striving to achieve a goal
    m. I know that everything has a certain order and a logic for working it out
    n. When I experience a problem, I can think about everything which might cause it
    o. I use carefully compare options and make a decision
    p. When performing a task, I try to decide on my next step

Section 3: The following questions ask about your attitudes towards problem solving in your classes this year.

7. How much do you agree with the following statements? (Response options: Strongly disagree, Somewhat disagree, Not sure, Somewhat agree, Strongly agree)
    a. I can usually figure out a way to solve problems in this class
    b. After I study a topic in this class and feel that I understand it, I have no difficulty solving similar problems on the same topic
    c. If I want to apply a method used for solving one problem to another problem in this class, the problems must involve very similar situations
    d. I usually spend more than five minutes stuck on a problem in this class before giving up or seeking help from someone else
    e. A significant problem in learning the content in this class is being able to memorize all the information I need to know
    f. Understanding the content in this class basically means being able to recall something you've read or been shown
    g. If I get stuck on a problem in this class, I can usually figure it out on my own
    h. There is usually only one correct approach to solving a problem in this class
    i. To learn the content in this class, I only need to memorize solutions to sample problems

Section 4: Below are several questions about yourself. For each question, check the box that you think describes you the best.

8. What is your date of birth?
9. What is your gender?
    a. Male
    b. Female
    c. Nonbinary
    d. Prefer not to answer
10. How would you identify your race or ethnicity?
    a. White
    b. Hispanic or Latino
    c. Black or African American
    d. Native American or American Indian
    e. Asian/Pacific Islander
    f. Other
    g. Prefer not to answer

11. What is the highest level of school your parents/guardians have completed? (Response options: Some high school, High school graduate, Some college, College graduate, Graduate school, Professional school, I don’t know/prefer not to say)
    a. Parent/guardian 1
    b. Parent/guardian 2
12. What grade in school are you in this year?
    a. 5th
    b. 6th
    c. 7th
    d. 8th

Appendix E. Additional Analysis Results

Exhibit E1. Psychometric Results for the Attitudinal Scales

Construct	Item	*R*	α
Student Survey			
Problem-solving transfer	1. I can usually figure out a way to solve problems in this class.	.56	.70
	2. After I study a topic in this class and feel that I understand it, I have no difficulty solving similar problems on the same topic.		
	3. If I want to apply a method used for solving one problem to another problem in this class, the problems must involve very similar situations.		
Fixed mindset toward problem solving	4. I usually spend more than five minutes stuck on a problem in this class before giving up or seeking help from someone else.	.71	.69
	5. A significant problem in learning the content in this class is being able to memorize all the information I need to know.		
	6. Understanding the content in this class basically means being able to recall something you've read or been shown.		
	7. If I get stuck on a problem in this class, I can usually figure it out on my own.		
	8. There is usually only one correct approach to solving a problem in this class.		
	9. To learn the content in this class, I only need to memorize solutions to sample problems.		
Post-Implementation Teacher Survey			
Value of the Pack	10. I am excited to continue to use The Pack in my classroom.	.60	.84
	11. Using the Pack helped me to develop students' understanding of key concepts in my classroom.		
	12. Using the Pack helped me to develop students' approach to solving problems in my classroom.		
	13. I had to give up a lot of other important content in order to implement The Pack in my classroom.		
	14. Using The Pack in my classroom required too much effort.		

Note. R = Rasch person reliability; α = Cronbach's alpha

Exhibit E2. Student Responses to the Item "To what extent do the following statements describe how you play the Pack?"

Item	*N*	Not at all	A little	Some-what	Very much so
a. I try to see how far into the desert I can take my avatar before the water drop gets too big and I get sent back on the map.	82	11%	20%	34%	35%
b. I try to dig or build in ways that cost as little fruit as possible so I don't have to waste time collecting fruit.	82	9%	22%	32%	38%
c. I use my pack to find fruit for me instead of looking for fruit with my avatar.	80	23%	25%	25%	28%
d. I use the repeater so that my algorithms use less fruit.	82	16%	12%	37%	35%
e. I leave creatures in areas on the map where they tend to be most useful and then come back for them when I need them.	82	32%	25%	29%	15%
f. I use the map to locate water so that I can dig a canal in the right direction, toward a seed on dry land.	82	7%	17%	35%	40%
g. I use parts of the same algorithm to get food in different ways (e.g., from underground, or from a tree)	81	6%	21%	40%	33%
h. I create general algorithms that I can change slightly to accomplish different tasks.	82	4%	22%	38%	37%
i. I wander around the map to locate as many seeds as I can before I start collecting them.	81	14%	22%	32%	32%
j. I collect a lot of food of different types before I start using it to collect seeds.	81	1%	14%	41%	44%
k. When I encounter a seed I can't get to, I start by thinking of how I need to change the environment to get to it.	82	4%	17%	34%	45%
l. When I encounter a seed I can't get to, I start by thinking of how the creatures in my pack can be combined to help me reach it.	81	1%	14%	37%	48%
m. If I can't get to an area from one direction, I look to see if there are alternative paths to get there.	80	8%	15%	31%	46%
n. I will usually try to dig or build something first, see if it works or not, and then adjust.	80	8%	19%	38%	36%
o. Before trying an algorithm, I will test it and make changes until it does what I want.	81	14%	27%	31%	28%

Item	*N*	Not at all	A little	Some-what	Very much so
p. Even if one algorithm works, I'll try to make another one that does the task in a better way.	81	15%	30%	33%	22%
q. I decide where I should go and what I should do next based on where on the map I haven't explored yet.	82	5%	18%	42%	35%
r. I plan out how many spaces I would need to dig to get water to reach dry areas.	82	12%	27%	35%	26%
s. I think about the steps needed to change the environment in different ways.	82	11%	22%	34%	33%
t. I find complex ways to combine creatures in a certain order to accomplish the next task.	81	5%	17%	47%	31%

Exhibit E3. Regression Results From Analysis of the Extent to Which Student Attitudes Toward Problem Solving Is Associated With Student Use of The Pack.

Independent Variable	Problem-solving transfer			Fixed mindset toward problem solving		
	B	*SE*	*p* value	*B*	*SE*	*p* value
Student use of the Pack	.28	.20	0.171	.21	.14	0.138

Exhibit E4. Regression Results From Analysis of the Extent to Which Student Computational Thinking Skills Are Associated With Teacher and Student Use of The Pack and Student Problem-Solving Approaches

Independent Variables	*B*	*SE*	*p* value
Use of The Pack			
Teacher use of the Pack	.013	.008	0.873
Student use of the Pack	–.06	.017	0.457
Student Problem-Solving Approaches			
Break down problems	–.0001	.020	0.999
Find patterns	.084	.018	0.327
Revise solutions	–.014	.018	0.867
Generalize to other problems	–.027	.018	0.739
Develop a rule	–.14	.019	0.090
Make changes to solutions	–.07	.019	0.382

Appendix F. School Demographic Information

Appendix F provides detailed information about the study's school sample. School names have been deidentified to ensure participant confidentiality.

Exhibit F1. School Demographic Data of Participating Schools

School	Grades served at school	% Black or Hispanic	% English learners	% Students with disabilities	Economic Need Index
School A	6–8	79%	6%	27%	84%
School B	6–8	89%	12%	23%	77%
School C	6–8	98%	41%	32%	> 95%
School D	6–8	96%	19%	22%	94%
School E	K–8	65%	6%	16%	71%
School F	6–8	97%	28%	17%	90%
School G	K–8	93%	18%	17%	90%
School H	6–8	60%	19%	19%	81%
School I	K–8	87%	21%	25%	82%
School J	6–8	95%	8%	25%	86%
School K	6–8	94%	13%	21%	91%
School L	K–8	56%	17%	15%	88%
School M	6–12	94%	6%	10%	82%
School N	6–8	93%	23%	22%	85%
School O	6–8	94%	10%	25%	89%
School P	6–8	38%	25%	17%	74%

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